

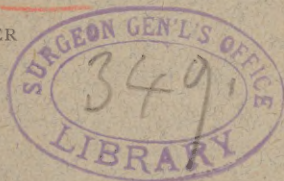
STEVENS, (G. T.)

THE ANOMALIES OF THE OCULAR
MUSCLES

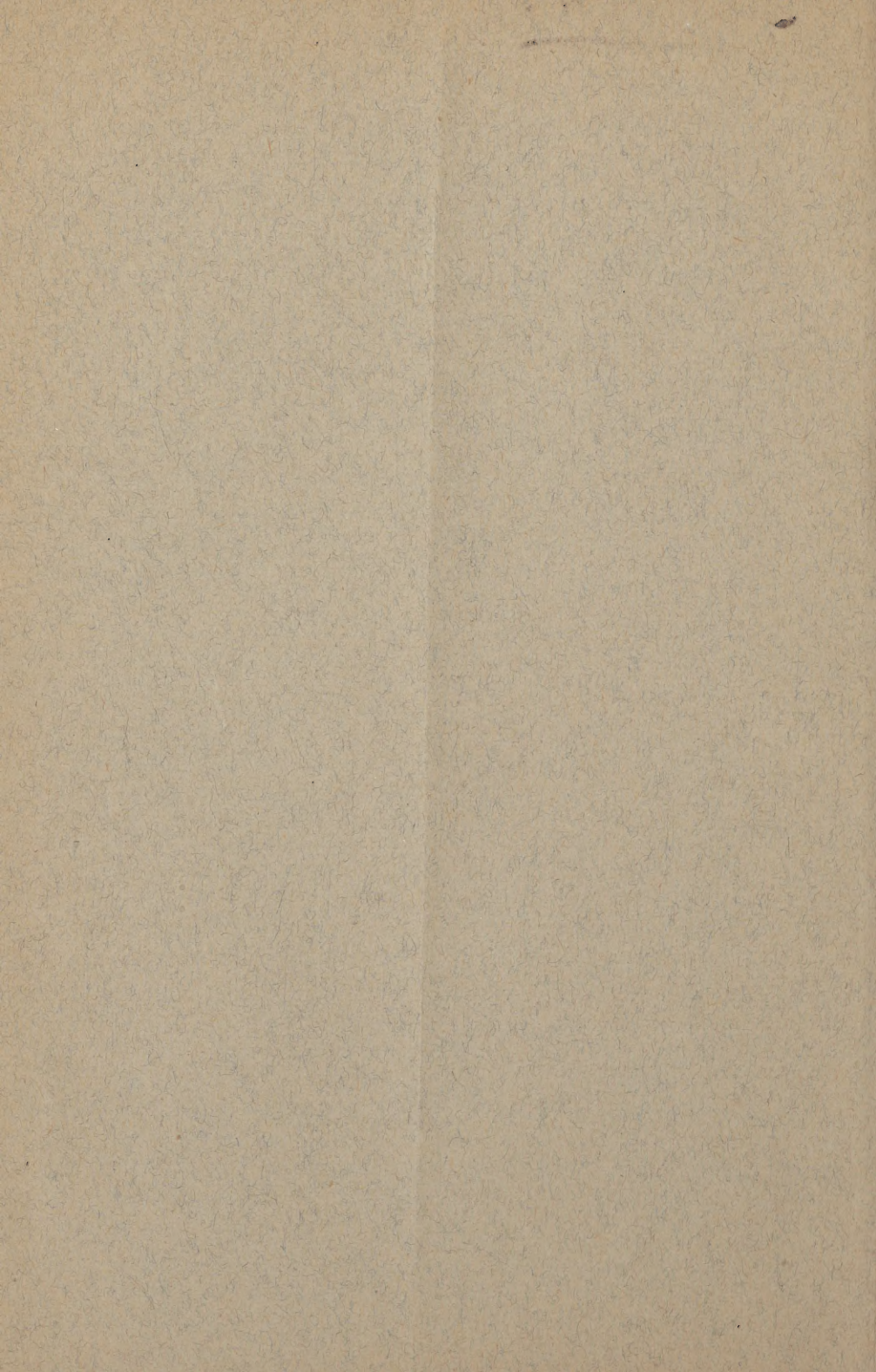
BY

DR. GEORGE T. STEVENS, NEW YORK

FIRST PAPER



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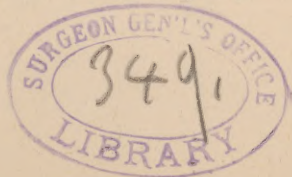
I.

AFFECTIONS of the ocular muscles may be divided into those which are physiological peculiarities and those which result from pathological conditions. It is proposed now to consider the first of these two groups.

In the normal adjustments of the eyes in the act of vision, two distinct classes of muscles perform each its separate office. The muscle of accommodation situated within the eyeball acting as focal adjuster for each eye, while the long muscles within the orbit direct the eyeballs in such a way as to bring the visual axes of the two eyes to bear upon the point for which the focal adjustment is made.

The two classes of muscles are in a sense independent of each other, yet in a very important sense in close and interdependent relation. In the discussion of the anomalies of the ocular muscles, then, the relation of these two classes is to be constantly regarded. The affections of the ciliary muscles, constituting the essential factor in the subject of the accommodation of the eye, become a subject of special study, and not to be considered in this connection further than in respect to the reciprocal influences of the two classes of muscles.

Such special conditions of the muscles of accommodation as may be necessary to refer to in order to obtain a proper understanding of their relations with the class of muscles more directly under consideration will be introduced as occasion demands.



The subject of anomalies of the directing muscular apparatus of the eyes divides itself again into two classes: first, those which permit of habitual binocular vision; second, those in which a blending of the images of the two eyes is so difficult as to be, in most instances, impossible. In the first of these two classes of faults, binocular vision is maintained by the expenditure of a greater amount of force than is demanded in perfect equilibrium of the ocular muscles; in the second, a psychical disturbance results which may have an important bearing upon the general physical condition of the individual subject of the anomaly. The two classes are in reality but different degrees of similar affections, and the classification depends upon the psychical presence or absence of the phenomenon of a fusion of images. Indeed, under certain circumstances, one of these conditions may pass into the other, and one who, in robust health, blends images habitually and with difficulty may, in a condition of impaired nervous energy, be quite unable to maintain a fusion of the images of the two eyes. Even the presence or absence of binocular vision, then, does not constitute an absolute and sharply defined line of classification. It also often happens that, with gross departures from the standard of equilibrium of the ocular muscles, habitual binocular vision is sometimes maintained, while in other instances comparatively moderate anomalies give rise to diplopia.

Such conditions must, however, be regarded as exceptional, and if the boundary, the sustained presence of single vision, like many of the boundaries of classification in science, is sometimes vague, it will on the whole be found practical and satisfactory.

Directing our observations first to the class of anomalies in which habitual binocular vision is maintained, we shall find a theme rich in interest and of pre-eminent importance in its practical bearing.

While it is true that some of the most illustrious names among those who have contributed to the notable progress of modern ophthalmology have been identified with the discussion of this subject, it is nevertheless also true that,

considered in respect to its importance, comparatively slight attention has been bestowed upon it in the literature devoted to ocular affections. For the most important expositions in this department of ophthalmology we are indebted to Von Graefe, who left to the world, among his richest contributions to the literature of science, extensive memoirs upon subjects connected with the ocular muscles, replete with learning and original research. Investigators from his time have been, in large measure, content to accept the results of his splendid genius as in the main conclusive, and since his death it cannot be said that any very striking advance has been made in this direction. But Graefe's observations were those of a pioneer. They were not exhaustive, indeed they were, in respect to the class of affections now under consideration, incomplete and confined mainly, it may be said almost exclusively, to a single anomaly among several, and that one, as it will be seen, not the one of greatest practical importance. In these muscular affections in which, with absence of equilibrium the ability to maintain binocular vision remains, there is a tendency on the part of the eyes to permit the visual lines to deviate from parallel directions. Graefe, with others, taught that when the ocular muscles are all accurately proportioned in respect to their dynamic conditions, and the performance of binocular vision is accompanied with the least expenditure of energy, the ocular muscles are to be regarded as in "equilibrium." The tests, however, which have been applied to the determination of the presence or absence of equilibrium have not in all cases been sufficiently trustworthy, and it is desirable in the beginning of this discussion to determine precisely what is indicated by the term equilibrium, and to establish definite means of ascertaining, by the most conclusive methods attainable, the true conditions of the muscles in this respect.

Graefe regarded the ability to direct the axes of the two eyes to the same point, at the usual distance of reading, without excessive effort, as a practical standard of equilibrium, and taught that this should be gained even at the expense of very great loss of equilibrium at greater distan-

ces. Thus, in operating for relief of "insufficiency of the interni," he was ready to induce very high degrees of "insufficiency of the externi," or even homonymous diplopia at a distance. As Graefe's operations were in large measure designed for the relief of "insufficiency of the interni," in cases of high grades of myopia, the great disadvantages of the loss of equilibrium at a distance were less pronounced than would have been the case under other circumstances. Such a standard of equilibrium should not be accepted. Equilibrium does not exist when comparatively easy fusion of images is gained at one point at the expense of difficulty or impossibility of fusion at another.

In equilibrium, the visual lines of the two eyes should be parallel when the force of the will in accommodatating or adjusting the eyes is removed—that is, when the minimum of nervous impulse is directed to the ocular muscles. Deviations from a given standard of equilibrium short of the loss of power of fusion of images have been known as "insufficiencies." The term has, however, been mostly applied to an inadequate converging power for the distance of reading or ordinary work, and it has often, even by Graefe, been employed in connection with low grades of actual strabismus.

In the conditions of absence of equilibrium now under consideration, and as they will be discussed in this paper, there is, in the act of vision, no actual turning of one visual line in a direction differing from that of the other when looking at a distant point. Indeed, in gazing directly forward at a distant object parallelism is supposed. There is, however, in these conditions, on the part of some one or more muscles, a tendency to disturb the balance; and should the nervous control be so removed as to permit of the consummation of this tendency, an actual deviation would result. Such irregular tendencies, then, may exist in as many directions as there are forces to induce irregular tension—that is, not only in as many directions as there are muscles to act, but in as many directions as the muscles may combine to act. In short, then, these tendencies may exist in all directions. Without stopping here to discuss

the question whether it is important to discover and to estimate the degree of all these deviations—a subject which will engage our attention further on,—we may here assume that all are important, and that no just appreciation of the conditions which induce asthenopic or kindred troubles can be acquired which does not take them all into account. It becomes necessary, then, to establish some method of investigating and of recording such anomalies.

So long as the increased tension upon the interni, in the act of reading, or in other continued work at a like distance, was regarded as the main, if not the only important factor in the causation of muscular fatigue, aside from accommodative lesions, the test of the dot and line, as suggested by Graefe for this condition, appeared to answer the requirements. This familiar test was made at reading distance, although Graefe counsels that, after having determined the degree of insufficiency for this distance, we should examine in the same way for greater distances. Without specifying the distances, he, in close relation to this part of the discussion, mentions his experience at abduction and adduction at a distance of six feet. This counsel, to determine the insufficiency at greater distances, judging from the literature of text-books, has been mainly disregarded, and indeed Graefe himself considered it of secondary, if not in most cases of little importance. The facts remain that in respect to this one test for a single condition there is not a well-established rule or custom. Even were complete uniformity observed in the examinations or records of this condition of the ocular muscles, this method is quite inadequate for the determination of several other conditions, and, as will be seen hereafter, extremely unreliable even for this one.

No just appreciation of the muscular balance can be arrived at while the accommodation is considerably exercised. Hence the principal determinations should be made at such distance as to render the accommodation practically relaxed, and while the determination of the inclination of the visual lines in the act of accommodation may be of importance, and may throw some light upon the false tenden-

cies, it should not be regarded as a method representing the presence of equilibrium or of the degree of deviation from it.

Elsewhere¹ I have discussed the manner in which one may discover these faulty conditions. In order that in what is to follow there may be no misunderstanding, that the conditions under which the investigation of these visual tendencies are to be made and the manner of making them may be definitely understood, I trust that I may be pardoned for restating in as brief a manner as possible what was there more fully discussed. The head being in the "primary" position and the ocular muscles relaxed, while ametropia, if existing, is corrected by appropriate glasses, the subject of examination directs the eyes at an object, preferably a lighted candle against a dark background, situated at the distance of twenty feet. Diplopia is then produced by a prism. First of all diplopia should be produced in the horizontal direction, in order to determine the relative tendencies of the visual lines in the vertical meridian. If the prism is first employed with its base up or down, and especially if it is held before the eye for some seconds, there will follow a partial adjustment of the visual axes to the new condition, and if then the prism is placed horizontally, this temporary adjustment may appear in the test which is about to be made. A very slight adjustment of this kind is of much less importance in the tests for the lateral relations. A prism sufficient to prevent fusion of images at the given distance, but not so strong as to cause a wide separation of the images, is to be placed with its base inward and exactly horizontal. If now the two images of the object looked at appear to be precisely in the same plane, no tendency of one visual line to rise above the other has been shown. If on the other hand the images appear not in the same plane, a prism should be placed before one eye with its base up or down, and of such grade as will bring the mounting line down or the depressed one up to the plane of the other. The degree of prism marks the

¹ *Archives d'Ophthalmologie* (Paris), Nov., 1886; *New York Medical Journal*, Dec. 8, 1886.

ascertained degree of tendency to deviate from the plane. For convenience in making this determination I have had made several pairs of spectacles containing, in each side, prisms of equal grade, 5° , 6° , and 7° each, with their bases in. The glasses are quite long and in the form of a parallelogram, in order that their exact position on the face may be accurately known. These spectacles are convenient in saving time and in assisting toward greater accuracy in the examination than is likely to be obtained by the use of the ordinary trial frame or from prisms held in the hand.

This test having been made with care, the prism is then placed before one eye with its base up or down. Graefe used a prism of 15° ; for his tests were made at near range, but one of 7° or even less will, in ordinary cases, induce diplopia, and permit of more accurate judgment of the relative position of the images on the part of the patient. Any deviation from the vertical line is to be measured by the prism which will bring the images in line, as suggested by Graefe. By turning the first prism a certain number of degrees until the correction is made, we may also, the grade of the prism and the degree of the turning being known, estimate the degree of deviation. By these two procedures information in two very important directions is obtained; but the absence of positive evidence of anomalous tendencies, as shown by these tests, does not by any means prove the presence of equilibrium, and other means must be tried. Here the method of producing abduction and adduction is to be resorted to, not, however, at six but at twenty feet.

An experience in many thousand examinations leads me to believe that the standard of normal abduction should be about 8° , and that of adduction at about 50° . In respect to this last, however, the ability to overcome prisms equal to 50° implies, in most cases, an ability indefinitely exceeding this, and many who at the first trial can accomplish only one half of this will, after two or three attempts on different days, succeed in uniting images with the full strength of the adducting prisms. On the other hand, while the failure to overcome at twenty feet a prism of 8° with its base in

should be regarded as suggesting an excess of energy over the others on the part of the interni, and while power to overcome a higher prism suggests a balance in the opposite direction, many cases occur in which the absence of ability to overcome a prism of 5° does not prove an inward tendency of the lines, nor does the blending with a prism of 10° or 12° prove a tendency outward. The ability to overcome a very strong prism with its base inward may be associated with actual converging strabismus, and the failure to overcome a comparatively weak one may be associated with an outward balance.

These results are to be compared with those already obtained by the diplopia tests when the prism is held vertically, but especially should they be considered in regard to any tendency of the visual axes to deviate in respect to the horizontal plane, for, as it will be seen, a very slight anomaly in this respect may modify the abducting or adducting power materially. In a like manner also, the ability to overcome a prism with its base up or down should be ascertained. Graefe declared his inability to overcome a prism of more than one degree in this direction at six feet, and states that, for nearly all those whom he tried, a prism of 2° was too strong. My own experience varies from this, for I have found that a very large proportion of the persons whom I have examined can overcome 2° or 3° at twenty feet, and I should place the average ability in cases in which no false tendencies exist in this direction at about 3° . It is not very uncommon to find persons who will overcome 9° or more in this direction. But it would appear to be of slight consequence whether the adjusting ability in this direction is rather more or less than 3° , if the power in one direction is equal to that in the other. An excess of power, however, leads to the suspicion that excessive demands arising from anomalous conditions have been imposed upon the muscles. The adjusting power is, in this respect, to be proved by placing the strongest prism which can be overcome before one and then the other eye in the same manner, or by reversing the prism before the same eye; for the effort at overcoming a prism with its base

down before one eye, is identical with that for uniting with its base up before the other. If we consider the results of the examination in the horizontal direction in relation to those in the vertical, we shall be able to form an opinion concerning the presence or absence of equilibrium, and, if manifest deviating tendencies exist, of the direction and extent of such tendencies. It is not, however, to be assumed that these indications are absolute. They are, as a rule, correct so far as they are positive, but they do not of necessity permit us to determine the absolute degree of deviating tendency. Here, as in hyperopia, a latent anomalous tendency may exist but, unlike hyperopia, we have here no means of ascertaining at a single examination the absolute departure from the ideal standard. Notwithstanding no proof may have been obtained by these trials, latent tendencies of great importance may exist. Our tests determine the manifest conditions only, and it is a safe rule to consider that the deviating tendencies are never less than are shown by our trials, but that they may greatly exceed that which we are able to demonstrate.

Having determined in this manner the approximate condition of muscular adjustment when no effort of accommodation is demanded, we may proceed to a similar examination at a near point. For convenience we may adopt the distance at which the majority of people hold the page when reading. Tests made at the distance of one half metre will sufficiently indicate the tendencies when the eyes are in accommodation for near work. Here prisms of greater angle than those employed for producing diplopia at a distance will be required, but the determinations may be made in the same general manner. Presbyopic persons should be supplied with reading-glasses in making this test, and the glasses for myopes should be such as are suited for the prescribed distance.

Terms by which we may express all the deviating tendencies which may be discovered in the manner indicated have been wanting. The imperfections of the nomenclature for ocular muscular anomalies have been discussed by myself in the articles already referred to, and a system of terms has

been suggested. While, in order to avoid misunderstanding, the terms already familiar will, to a certain extent, be employed in this discussion, those which I have proposed will be used as the standard, and without apology for the innovation beyond what I have expressed in the former papers. The signification of these terms is repeated here:

"I. Generic terms. *Orthophoria* (ὀρθός, right, φόρος, a tending): a tending of the visual lines in parallelism. *Heterophoria* (ἕτερος, different): a tending of these lines in some other way.

"II. Specific terms. Heterophoria may be divided into: (1) *esophoria*: a tending of the visual lines inward; (2) *exophoria*: a tending of the lines outward; (3) *hyperphoria* (right or left): a tending of the right or left visual line in a direction above its fellow.

"This term does not imply that the line to which it is referred is too high, but that it is higher than the other, without indicating which may be at fault.

"III. Compound terms. Tendencies in oblique directions may be expressed as *hyperesophoria*, a tending upward and inward; or *hyperexophoria*, a tending upward and outward. The designation 'right' or 'left' must be applied to these terms.

"In recording the respective elements of such compound expressions I have employed the sign \perp . For example, if it is desired to indicate that the right visual line tends above its fellow 3° , and that there is a tending inward of 4° , the facts are noted thus: Right hyperesophoria $3^\circ \perp 4^\circ$."

II.

HYPERPHORIA.

By hyperphoria is meant the condition of the ocular muscles in which, with a minimum of tension, a deviation of one visual line above the other would result. Habitual binocular vision is assumed, although we shall see that it is probable that in a considerable proportion of cases in which hyperphoria of more than a single degree exists, the tendency to diplopia is so great that the subjects of the

affection often surrender to it—a fact confirmed by the marked amblyopia often found associated with this muscular condition.

Among the varieties of heterophoria none exerts a more disturbing or injurious influence than hyperphoria. It is not only a condition giving rise in itself to great fatigue and perplexity, but it complicates and exaggerates all other faulty tendencies. When we recall the fact that with a fair adducting power one may overcome prisms of 50° with the base to the temples, and that with a good abducting ability a prism of 7° or 8° is easily overcome in the opposite direction, it will be apparent that muscles which do not ordinarily overcome more than a prism of three degrees, as is the case when the prism is placed with its base up and down, must be in a condition of great disadvantage when hyperphoria of one or two degrees exists. If we were to compare the relative nervous impulse demanded by the grade of the prism, which can be overcome in the different directions, then a deviating tendency of one visual line above the other (hyperphoria) of one degree would be equal to a deviating tendency outward (exophoria, insufficiency of the interni) of more than fifteen degrees. In other words, a faulty tendency of one or two degrees in the vertical direction falls little short of a diverging strabismus in importance. That this is actually nearly the relative importance of the two conditions appears evident from several considerations which arise from conditions found associated with hyperphoria. These conditions are local and remote. The local relate directly to the function of vision, to the adjustments of the eyes in the performance of the visual function, and to nervous disturbances of a functional or trophic nature in and immediately about the eyes.

The remote conditions relate to a great variety of disturbances of a nervous character in parts more or less removed from the eyes.

Hyperphoria of a low grade, as determined by a correcting prism, is very frequently attended by amblyopia. It is no unusual occurrence to find, in a case of hyperphoria which may be measured by a prism of 1° or 2° , vision of

only $\frac{2}{40}$ or even less, while the refractive conditions are not far removed from emmetropia, and the ophthalmoscope reveals either no pathological state or only a slight tendency to the hyperæmia about the disc which is characteristic of irritability of the eyes from muscular irregularities. The relative number of cases in which such defective visual power exists will, to one who has not well considered the subject, appear to be out of proportion to the muscular defect. The surprise will, however, give place to conviction if we bring clearly to mind the actual effects from the standpoint of physiological optics, of a very slight faulty tendency in the vertical direction. An actual deviation of a single degree would result in a separation of images at a distance of one half metre, approximately of 6.4 mm. A patient, then, with this amount of deviating tendency, who would bring the letters of the type in which this page is printed, even in contact, the lower border of the upper image touching the upper border of the lower, would require to exert a force upon the superior and inferior muscles greater than Graefe was able to exercise. If, however, by long practice, the muscles engaged in overcoming this fault acquire unusual strength, as is actually the case, still, when the tension has been continued for a considerable time, or when the general nervous tone is diminished from fatigue or ill health, an almost irresistible tendency to diplopia will occur. The remedy for the confusion thus induced is a renewal of the inordinate muscular tension or the suppression of the image of one of the eyes. This later really takes place, and the image suppressed is liable to be that of the eye in which greatest refractive anomaly is found, if a difference exists, or if the eyes are equally well adapted for clear vision the suppression occurs alternately. Hence, with a greater refractive anomaly in one eye, amblyopia will usually be found principally in the less perfectly constructed eye, while if the eyes are nearly or quite alike, the amblyopia will exist equally in the two eyes. Exceptions to this rule exist, especially in cases where, with myopia as the ametropic condition, the myopic eye is employed at the near point, while the more perfect eye is used for distant seeing.

The extent to which amblyopia exists in connection with hyperphoria is illustrated in the following tables. One hundred consecutive cases in which there existed hyperphoria, and in which no disease or injury of the eyes was found, and in which the refractive errors were not sufficient to account for any considerable defect of vision when correcting glasses were used, are included in the tables, excluding cases of high grades of refractive errors. The highest grade of astigmatism not exceeding 3.00 D, the highest of hyperopia not exceeding 4.00 D, and the highest of myopia not exceeding 5.00 D.

TABLE I.

Refractive error.	1.00 D or less.	More than 1.00 D; not exceeding 2.50 D.	More than 2.50 D to 4.00 D.	More than 4.00 D to 5.00 D.	Total.
Emmetropia					45
Myopia	9	19	7	7	42
Hypermetropia	37	24	12		73
Astigmatism	28	7	5		40
	74	50	24	7	200

Acuteness of vision.	Refractive error.						Total.
	1.00 D or less.		More than 1.00 D; not exceeding 2.00 D.		More than 2.50 D; not exceeding 5.00 D.		
	Best eye.	Worst eye.	Best eye.	Worst eye.	Best eye.	Worst eye.	
20	38	21	7	7	4	4	81
30	22	15	8	8	1	5	59
40	6	8	3	7	3	4	31
50	1	2	2	5	1	2	13
60	1	1	1	2	2	2	9
70		3				2	5
80		1				1	2
90							
100							
200							
Total	68	51	21	29	11	20	200

In the first table the proportion of eyes affected with different grades of refractive errors is shown; in the second, the acuteness of vision according to the refractive condition.

The vision of the best- and worst-seeing eyes in each grade is given but for convenience, in the estimate of the comparative value of the best and worst, in all cases where vision is equal in the two eyes one is reckoned as best and the other worst. If anisometropia exists to the extent of bringing the refractive conditions of two eyes in different columns, the vision of one eye only is placed in each column.

From the above tables we obtain the following approximate results:

Average Vision of Best Eyes.

Sixty-eight with less than 1.00 D refractive error, $\frac{1}{3}\frac{6}{10}$.

Twenty-one with more than 1.00 D and less than 2.50 D refractive error, $\frac{1}{2}\frac{3}{10}$.

Eleven with more than 2.50 D and less than 5.50 D refractive error, $\frac{1}{2}\frac{3}{10}$.

General average of vision of 100 best eyes, $\frac{2}{3}\frac{0}{10}$.

Average Vision of Worst Eyes.

Fifty-one with less than 1.00 D refractive error, $\frac{1}{2}\frac{4}{10}$.

Twenty-nine with more than 1.00 D and less than 2.50 D refractive error, $\frac{1}{2}\frac{2}{10}$.

Twenty with more than 2.50 D and less than 5.50 D refractive error, $\frac{1}{2}\frac{1}{10}$.

General average of vision of 100 worst eyes, $\frac{2}{3}\frac{0}{10}$.

It will be seen from the above table that defective vision is rather the rule than the exception in moderate degrees of hyperphoria. It is a fact that must have occurred to every experienced oculist, that in anisometropia a material difference in the visual power of the two eyes is exceedingly common. But it is also true that in anisometropia a difference in the form of the orbit is quite common, a fact which would tend to a failure of equilibrium in the length or strength of the motor muscles of the eyes. Experience

confirms this reasoning, and I have found that instances of even approximate balancing of the eye muscles in anisometropia is rather exceptional.

From the facts thus ascertained it becomes evident that amblyopia is not only very commonly associated with hyperphoria, but that it is not uncommonly a result of that anomalous condition.

A peculiar and interesting visual disturbance, related to yet differing from amblyopia, is the inability of the subject to see small objects clearly, although for larger objects, at the distance of some feet, the visual power is fair or even good. Thus, one may be able to read No. XXX., or even No. XX. of Snellen's scale, and may have no especial fault of accommodation, yet when No. I. is presented at the distance of one foot, the patient is quite unable to read. Small objects or characters are seen indistinctly or not at all. The fault in these cases appears to consist in an inability completely to fuse the images of the two eyes, while the separation is not sufficiently great to enable the patient to easily suppress one of them. This phenomenon is illustrated in the confusion which appears when one reads the word here doubly printed: *Accommodation*. If we cover with a card the lower range of type, the word is perfectly clear. A corresponding result may be effected in a considerable degree of hyperphoria by the mental suppression of the upper or lower rank of letters. If, however, the separation is less complete, as in this instance:

Accommodation we are quite unable to exclude either of the confusing ranks, as in the former experiment with the card, and the difficulty of a mental exclusion on the part of the subject of hyperphoria in this latter case is likewise greater than in one of more complete displacement. That only a comparatively small proportion of hyperphoric persons experience in marked degree this inability to see small objects well, is probably to be accounted for on the principle that in the great majority of instances the subject of hyperphoria is able either to fuse the images completely, or to displace them to such an extent as to enable a mental exclusion of one image to take place.

The conditions in hyperphoria relating to the adjustments of the eyes through the influence of their motor muscles are extremely interesting and important. The disturbing effects upon the lateral equilibrium is especially noticeable, and is a source of great perplexity to the oculist in his examinations of the muscular conditions. In hyperphoria the tests for lateral deviations are very often contradictory, and in a very considerable proportion of cases unsatisfactory. Unless the examiner is on his guard against the anomaly under consideration, he is liable to fall into grave errors of diagnosis and of practice. These errors are especially liable to occur if we rely for evidence for muscular balance upon the near test as suggested by Graefe. By such a trial we are, in moderate degrees of hyperphoria, likely to find extreme grades of "insufficiency of the interni," when in fact, if the test is made at a distance of twenty feet, the contrary condition is found. It is not an unusual occurrence with the existence of a single degree, or even less, of hyperphoria, to observe with actual esophoria of 2° or 3° (prism) an apparent exophoria in accommodation of 10° or even 15° . Such results illustrate forcibly the danger of relying upon the dot and line test, or upon any similar test at the near point, for determining the propriety of an operation for tenotomy of the externi. Indeed it will not be out of place to remark in the most emphatic manner that the test for "insufficiency" made at the near point should never be taken as a guide for an operation.

This principle of apparent contradiction is well illustrated in the following interesting case. A gentleman was found to have so strong a tendency of the visual axes to deviate inwards that at distances of twenty feet much difficulty was experienced in maintaining single vision. A relaxation of the force of the external recti muscles habitually resulted in homonymous diplopia. The insufficiency as measured by prisms was, however, not more than four degrees. On the contrary, if the gentleman held a pencil or his finger before him at the distance of fifteen or eighteen inches from his eyes, crossed diplopia occurred from "insufficiency of the interni." A pencil held at fifteen inches was doubled to such an extent

that the two images appeared about an inch separated. By the test of the dot and line the insufficiency was only about 6° or 7° .

This gentleman was found to have hyperphoria of 5° , and an operation for the relaxation of the superior rectus of one eye was made, followed a day or two later by relaxation of the inferior rectus of the opposite eye. On the day following the last operation there was no diplopia or even "insufficiency of the interni" at the near point, and binocular vision was maintained with ease at the distance. Several months later the gentleman again complained of double vision at near points, and it was found that hyperphoria of 2° in the same direction as before was now manifest. The inferior rectus of the upward tending eye was now advanced, bringing the visual axes to the same plane, when again the troublesome diplopia at the near points disappeared entirely.

A lady has crossed (heteronymous) and vertical diplopia, both for distant and near points. If a prism of 12° with its base down is placed before one of the eyes, she has at the distance of twenty feet "insufficiency of the externi" of 3° , but if no vertical prism is used, one of 4° with its base in will bring the two images to a vertical line, thus showing insufficiency of the externi with the strong vertical prism, and "insufficiency of the interni" without it. If now a prism of 6° with its base up before the right eye, or with its base down before the left eye, is used, the images of the two eyes blend perfectly.

Thus it appears that as the result of the deviating tendency upward an "insufficiency of the interni," both at near and distant points, may be simulated, while in fact the visual axes may be inward. Not only does the existence of hyperphoria often give rise to an apparent exophoria in accommodation when the real tendency of the eyes is inward, it also frequently presents the indications of exophoria at a distance while the abducting power is much restricted. We may, for instance, find exophoria 2° or 3° (prism), or even more, with a power of abduction not exceeding the apparent exophoria. Here is an evident contradiction, and

it may be, so long as the hyperphoria exists, impossible to determine whether our tests actually indicate an inward or an outward tendency of the visual lines, or neither of these conditions. It is because this important fact of the difference between the relation of the visual lines at a distance and those at near points has in many cases been overlooked, that surgeons of distinguished ability have sometimes performed tenotomy of the externi in cases of supposed "insufficiency of the interni" with the result of obtaining homonymous diplopia, without relief to the symptom of asthenopia. When once the hyperphoria is relieved by operation, we may hope for a more perfect determination of the condition of the lateral muscles. It is not proposed here to discuss the physiological reasons for the complications found in the muscular test when hyperphoria exists; this is a subject presenting many important difficulties, and the phenomena described can be fully explained only by actual experiments upon the muscles themselves. The evidences which may be found, however, that very marked "insufficiency of the externi" may exist when the accommodating and converging functions are at rest, and of "insufficiency of the interni," of possibly very high grade when these functions are exercised, illustrate the very unsatisfactory nature of the terms which have been so long employed in this connection, and appear to demonstrate that the use of terms having such opposite and misleading significations should be discontinued. The relation of myopia to muscular anomalies should occupy a prominent place in the discussion of the conditions dependent upon hyperphoria, but for reasons which will be given, that subject will be reserved for examination in the chapter on exophoria.

Another local affection caused by hyperphoria is hypersecretion of tears, by which the fluid fills the conjunctival sac and overflows the eyelids, causing much inconvenience and often disturbance of vision. These cases simulate the conditions found in obstruction of the nasal duct, and the absence of a general understanding of their nature is illustrated in the frequency with which such cases present them

selves for treatment, after having been subjected perhaps for many months to the process of probing the tear passages without any success in relieving the affection.

A branch of the fifth nerve supplies the lachrymal gland, and irritations to this nerve resulting from the efforts of correcting hyperphoria may result in so stimulating the gland as to induce the hypersecretion of tears, or it is quite possible that the pressure of the eyelids, which is often brought to bear to assist the ocular muscles in the performance of their duties, may expel the fluid from the gland in inordinate quantities.

Certain marked facial expressions and certain attitudes are characteristic, though not by any means constant in hyperphoria. Certain patients affected with this anomaly when looking indifferently, the eyes not specially directed to any object, will often present an appearance of moderate strabismus, more frequently diverging than converging. One of the eyes may even be observed to swing outward and then inward, giving a certain unsettled expression to the countenance. If, with even these strong indications of ocular deviations, tests for equilibrium are made, the result may be that either slight or even no evidence of lateral vicious tendency will be found. Involuntary convulsive contractions of the muscles of the face, giving rise to habitual distortion, constitute an important indication in some instances, of the efforts which are being made to overcome the effects of hyperphoria.

The habitual spasmodic closure of the lids of one eye should always direct the oculist's attention to the relations of the visual axes in the horizontal line. An effect upon the physiognomy not unfrequently observed is a rigid stare, the eyes being opened very wide, and all the facial muscles being apparently in a state of tension; associated with this peculiarity there is sometimes observed a tendency to snap the lids together forcibly and almost spasmodically.

The characteristic attitude of the head is even more striking and much more frequently observed. The head is carried toward the shoulder, usually to the side corresponding to the eye which tends below the other. This appears

at first thought to be quite inconsistent with the demands for relief. But when we remember that the object seen by the upward tending eye appears lower, and that seen by the downward tending eye appears higher, than the other, it becomes evident that by carrying the head toward the lowest tending eye the images of the two eyes are brought more directly into the horizontal line. In a certain proportion of these cases the contraction of the muscles of the neck becomes permanent, demanding for relief tenotomy of the tendons of the sterno-mastoid muscle; but in much greater number the muscles of the neck will regain their equilibrium either speedily or after some time, when once the vicious ocular tendency is removed.

This peculiar carriage of the head is much more common than would be supposed by one who has not specially investigated the subject. To a close observer familiar with the fact, the false relations of the eye muscles is very often reached even before any of the technical ocular tests are made. Graefe spoke of the turning of the face to one side in cases of "insufficiency of the interni," in order to obtain relief to the lateral muscles or to assist in the mental exclusion of one image. The attitude of carrying the head toward one of the shoulders in hyperphoria is even more characteristic and much more common, and in this case serves to permit of more easy fusion by raising one image and depressing the other. As has been observed above, correction of the deviating tendency of the eyes is followed by an habitual erect carriage of the head.

The more remote results of hyperphoria are those common to anomalies of the ocular muscles, but with certain special characteristics. Neuralgia, neurasthenia, insomnia, chorea, and epilepsy are among the manifestations of this condition. Much more than esophoria or exophoria is hyperphoria inducive of vertigo and epilepsy. The nervous disturbance arising from this cause is more perplexing, both from the difficulty in overcoming it by ordinary effort, and from the complications arising from it in respect to the converging and diverging efforts, than moderate grades of deviating tendencies in the lateral direction. Hence,

nervous phenomena of a higher intensity are liable to result from this condition. The constitutional effects of hyperphoria are well shown in the following illustration :

This case was seen and treated at the Willard Asylum for the Insane. It is proper to remark that this institution is not designed for acute cases, or those in which there exists a reasonable prospect of recovery. It is a home for incurables, and the case here reported was one of chronic epileptic mania belonging to that class. The history is given as it was furnished by Dr. P. M. Wise, the superintendent, and Dr. H. E. Allison, the physician under whose immediate charge the patient was.

M. L., female, aged thirty-six. Insanity commenced seven years previous to the present record, but the patient has been subject to epilepsy for an unknown period, certainly longer than the period of insanity. About once a month she is taken with a series of epileptic seizures, varying from three to eight or more, and at these times is liable to become greatly excited, the degree of excitement depending apparently upon the number of convulsions. A period of great exaltation and frenzy follows, during which she is furious, sings wildly, and shouts at the top of her voice, and is exceedingly destructive and violent. The paroxysm may last several weeks. When it has subsided, she becomes orderly, neat, and industrious, and usually continues so until another series of convulsions occurs.

She was first seen by me July 31, 1886. Examination of the eyes showed hyperopia of moderate degree and right hyperphoria 4° (prism). Glasses for the correction of the hyperopia were furnished, and tenotomy of the right superior rectus was made, followed within a few days by a similar operation upon the left inferior rectus. This final operation was made August 22d. Bromides, which had been previously freely administered, were withdrawn July 31st. August 26th, four days after the last operation, a period of moderate excitement, very much less pronounced than usual, commenced, which lasted until Sept. 12th. On Jan. 2, 1887, five months from the beginning of the ocular treatment, Dr. Allison wrote concerning Miss L. : "She has not, thus far, had any attack of maniacal frenzy, and only one attack (that which is above mentioned) of excitement, which was not great. She says

she has not had any convulsions. . . . She is very much improved, and feels very grateful."

A single other instance will suffice here to illustrate the constitutional effects of hyperphoria :

A lady gave me the following history of her physical condition : She had been subject to asthenopia, severe headaches, vertigo, and backache during all her life, and had hardly experienced any relief during her waking hours. Fifteen years before my acquaintance with her she had been insane, and had been taken to an insane asylum, from which she was removed after a period of nearly one year, but only to return. She was not free from illusions for nine years. With the restoration of reason a new form of nervous manifestation was exhibited. Habitual and frequent paroxysms of vomiting have now continued during several years. The paroxysm commences by seeing every thing in confusion, followed by an indescribable nervous sensation in the back, and finally by violent retching and vomiting, which is greatly intensified when the lady opens her eyes. The paroxysms continue from two or three days to several weeks ; the last attack lasted six weeks.

She was found to have right hyperphoria 5° . She was furnished for a time with prismatic glasses, which established a nominal correction of hyperphoria, and after a few weeks tenotomy of the superior rectus of the right eye was made. The paroxysms of vomiting did not return, the lady was relieved of the distressing pain in the head, and soon after the tenotomy she expressed herself as feeling in every way better than she had done during the past twenty years. The lady was not seen during several months, but when finally she did present herself, she complained of suffering again from symptoms of asthenopia, but no more from the general nervous condition. Hyperphoria of 2° was found still to exist, which could not be discovered soon after the operation was made. Another tenotomy has since been made, which has been followed by relief to the asthenopic symptoms.

It will be seen that attending this muscular anomaly, headaches, pain in the back, vertigo, insanity, and habitual vomiting constitute prominent features which followed this lady from infancy ; one form of trouble succeeding another, and possibly replacing it for a time, but from some manifestation of which she was never free until she was relieved

from the necessity of a most difficult and perplexing ocular adjustment. With this release came relief from the whole train of nervous symptoms.

Treatment of Hyperphoria.

The treatment of hyperphoria is tenotomy. If the patient is unwilling to submit to a radical relief, or if the surgeon hesitates to perform the operation, if complicating circumstances render such an operation inadvisable, other means may be resorted to. The use of a prism, with its base up or down, is indicated under such circumstances. Let it be remembered that while glasses are of inestimable value, they are still inconvenient and often extremely so ; that with the best art of the optician, glasses detract from the symmetry and expression of the face, a fact of much importance to females at least ; and finally, that in the conditions of muscular deviations, they neither cure nor afford as complete temporary relief as a removal of the actual defect. Indeed, it is not uncommon for one having hyperphoria of 1° or 2° to suffer much pain in or about the eyes while wearing a correcting prism, but to experience almost immediate and complete relief from all the symptoms caused by the mal-adjustment of the eyes, as soon as tenotomy is performed. Glasses are like crutches, desirable when defects which render them useful cannot be removed. A special disadvantage of a very weak prismatic glass is the fact that it reflects a false image of every strongly illuminated object, seen at some distance, just above or just below the true image. This false image is often extremely annoying.

The daily exercise, continued through two or three weeks, of overcoming prisms placed vertically before the eyes alternately, with the bases in the same direction or before the same eye with the prism reversed, may tend to give the muscles greater vigor, and hence to enhance their ability to endure the difficulty. The duration of the exercise should not exceed three to five minutes at a time.

If tenotomy is performed, the surgeon must choose between relieving the tension of the superior rectus of one or

the inferior rectus of the other eye. If it is evident that the defect can be located in one or the other muscle, of course his treatment should be directed accordingly. This is possible in a very considerable proportion of cases. The appearance of the eyes, when the patient's view is directed indifferently in space, will often aid in forming a correct judgment. The fact that, ametropia being corrected, the vision of one eye is less than that of the other, is a strong indication that this is the deviating eye.

If it is impossible, as in a certain proportion of instances it appears to be, to determine to which of the eyes the anomalous tendency is to be attributed, we are left to select upon more general principles the one to be subjected to the tenotomy. The inferior recti are those which possess the greatest power, and therefore a slight advantage taken from one of these in favor of the weaker muscle will, other circumstances being equal, cause, if possible, less change in the motile functions of the muscles than in the opposite case. If the hyperphoria is of considerable grade, it is better, unless there are very positive indications that the fault lies in a special muscle, to gain the relief by relaxing both the superior rectus of one eye and the inferior of the other. By this procedure, no practical restriction results to the movements of either eye in the vertical direction.

The method of performing tenotomy in these cases of deviating tendencies less than strabismus, has been described by me some years since.¹ Since that time I have found it advisable to modify the procedure somewhat, rendering the operation more simple and the results more satisfactory. As now performed, the eyelids being retracted, a fold of the conjunctiva is seized by a fine but rather rigid pair of mouse-tooth forceps, parallel with the course of the muscle and exactly over its insertion. With a pair of small narrow-bladed scissors, having blunt but very perfectly cutting points, a transverse incision is then made through the membrane, exactly corresponding to the line of insertion of the tendon. The conjunctival opening thus made

¹“Irritation oculo-névralie”: *Mémoire de l'Acad. Royale de Méd., Belgium*, 1883.

should not exceed in extent one fourth of an inch. With the forceps now pressing the outer cut edge of the conjunctiva slightly backward toward the course of the tendon, the latter is seized behind but very near its insertion. The distance may depend upon the freedom with which the intended section of the tendon is to be made. But in hyperphoria or in slight relaxations of the lateral muscles, a distance barely sufficient to allow a small part of the tendon to be raised from the sclera is all that should be allowed. Making some tension now with the forceps, the points of the scissors are directed against the central portion of the tendinous insertion and toward the sclera, when a small opening is made dividing the centre of the tendinous expansion exactly on the sclera. The small opening is now to be enlarged by careful snips of the scissors toward each border, keeping more carefully on the sclera as the border of the tendon is approached. As the section of the tendon is carried toward the borders, the outer blade of the scissors passes beneath the conjunctiva. If the relaxation of the tendon is to be slight, the extreme outer fibres of the tendon are to be preserved untouched; but if a considerable effect is desired, these fibres can be entirely severed, *provided that the reflection of the capsule of Tenon upon the tendon is not disturbed*. By means of the capsule acting as an auxiliary attachment, the tendon is held in position, but is allowed to fall back slightly while maintaining its relation to the eyeball. In this respect, and in preserving the outer tendinous fibres, this operation differs radically from the ordinary operation for strabismus, and from any operation which has been proposed for so-called "partial tenotomy" of the recti muscles.

The judgment of the operator must determine the extent to which the division should be carried, but should it be found that too little has been accomplished, the section can be extended. In doing this, the use of a very fine hook may be advisable. For this purpose a hook very much smaller and more delicate than the ordinary tenotomy hook should be employed. Its rounded point is carried under the remaining border of the tendon with great care,

to prevent hemorrhage or unnecessary disturbance of the connective tissues; the extension being made toward one and then toward the other border, as the demand for further relaxation may require. When the remaining band of fibres is made tense by the hook it is slightly elevated from the sclera, when the fine-pointed scissors are introduced beneath the conjunctiva, and the necessary extension of the wound is made with extreme caution not to divide the capsular attachment. The conjunctival suture should in no case be employed.

All bandaging of the eye or covers of any description are not only needless but mischievous. Indeed, if permitted to digress from the subject at issue, I would express my unqualified disapproval of bandages in nearly all operations about the eyes. During many years I have abstained almost entirely from the use of bandages in ophthalmic surgery, and know of no reason to regret this course. Bandages are promoters of heat, filth, and septicism. They have no possible advantage, and should, I believe, go out of fashion in ophthalmic operations. My own patients are permitted to return at once from the operating-room to their homes without regard to weather or the distance to be travelled. Many of them return on the day of the operation to their ordinary business.

In respect to the results of tenotomy for hyperphoria there would appear to be nothing in the range of surgery more satisfactory or certain. My first operations for the correction of a tendency of the visual lines to deviate in the vertical direction, and in which no vertical strabismus existed, were made in 1875. Very many were made in each succeeding year, but it was not, however, until during the past two years that the operation in my hands became as uniformly successful as could be desired. Now, with the procedure which has been described above, there is a great measure of certainty of success. During the year 1886 I performed tenotomy for the relief of hyperphoria one hundred and nine times in eighty-eight cases. The result in nearly every instance was, when the patient was last examined, a relief either partial or complete to the hyper-

phoria. In some instances in which, soon after tenotomy, no hyperphoria could be discovered, a partial return to the original condition has been found, and quite possibly this may be true of some who have not been seen since within a month or two of the operations. Of those in which a partial but incomplete relief to the hyperphoria has been accomplished, some are still under observation for treatment. Among these are two cases in which tenotomy of both externi has been performed by prominent oculists, in each instance leaving the patient with homonymous diplopia and pronounced hyperphoria, unless, in one instance, the vertical deviation should be regarded as an original vertical strabismus. In both instances nearly complete correction has been accomplished, and there seems no doubt that in the end equilibrium in all respects will be established.

Of the cases which have been stated to be correct when last seen, it may be repeated that it is possible that, at a future time, hyperphoria of a certain degree may become manifest. This happens in a proportion of cases after some weeks or months, and it is not safe to assume that no hyperphoria exists until many months after the operation.

In respect to the results of treatment of hyperphoria it is my purpose only to say here that the relief in uncomplicated cases is of the most marked, not to say surprising, character. Many patients who, from this cause, have suffered from distressing affections during many years recover, when this source of irritation is removed, with astonishing rapidity.

With little admiration for the practice of introducing slight modifications of well-known instruments as new designs, I think it reasonable, when the old instruments are evidently unsuited to new operations, to suggest such changes as will adapt them to the new conditions. It is in this spirit that I venture to describe such modifications of familiar instruments as I have found best suited to the operation for the relief of the ocular muscles as it has been described in this article.

The scissors have narrow yet strong blades, cutting perfectly at the points, which are blunt, in order that they may

not endanger the sclera. The blade is scarcely wider at the distance of half an inch from the point than at the point. This form permits the narrow blade to be insinuated between the conjunctiva and the insertion of the tendon with the least possible disturbance. I have found much difficulty in having scissors of this description made which, with the very narrow blades, should possess sufficient strength and perfect cutting qualities at the points. After several trials, Messrs. Meyrowitz Brothers have succeeded in producing an instrument combining these requirements.

The toothed forceps are so constructed as to combine much strength with delicacy at the working extremity. The branches are one fourth of an inch broad at their widest part, and taper but slightly until within one half inch from the toothed extremity, where they are suddenly contracted to a very narrow shaft, as fine as the most delicate iris forceps.

The hook is also quite delicate. From the stem, an inch in length, the hook extends by a short curve, at nearly a right angle, to the distance of three sixteenths of an inch. It is rounded and slightly probe-pointed at its extremity. The diameter of the hook and of the principal part of the stem is a little less than 0.5 *mm*, or of the size of No. 25 of Brown & Sharp's wire gauge.

